The claims before the Examiner are directed toward a method of determining the position and orientation of an object with respect to a reference frame. The object transmits electromagnetic radiation using three independent transmitters, each transmitter transmitting radiation at at least one respective frequency, with the frequencies of the second and third transmitters being different from the frequency of the first transmitter, and, preferably, different from each other. Signals corresponding to the transmitted radiation are received by three receivers at fixed positions in the reference frame. Each signal includes components of at least one of the respective transmitted frequencies. For each receiver, three functions of the received components are formed, each function including components of a respective transmitted frequency, with all the functions being independent of a time delay between the transmitters and the receivers. The position and the orientation of the object are inferred noniteratively from the functions, even if one or more of the receivers is spatially extended.

§ 102(b) Rejections - Acker '129

The Examiner has rejected claims 1-9 under § 102(e) as being anticipated by Acker, U. S. Patent No. 5,729,129 (henceforth, "Acker '129"). The Examiner's rejection is respectfully traversed.

Acker '129 teaches a magnetic location system in which a set of fixed transmitters **10** transmit respective DC or time-varying magnetic fields that are sensed by magnetic field component sensors **20**, **22** and **24** inside a moving object **14**. A command unit **28** receives signals from component sensors **20**, **22** and **24** and computes the position and orientation of object **14** from these signals. Command unit

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28 also adjusts the driving current of each transmitter **10** to keep the signals within acceptable ranges.

Although the teachings of Acker '129 include both DC excitation and time-varying excitation ("frequency domain multiplexing": column 11 line 13 *et seq.*), the emphasis of Acker '129 is on DC excitation. In particular, the algorithm described in Appendix A is specific to DC excitation: neither time nor frequency appear as variables in any of the equations of Appendix A. It therefore is not surprising that the functions of the received signals that are computed by command unit **28** are, like the analogous functions computed according to the present invention, independent of a time delay between transmitters **10** and component sensors **20**, **22** and **24**. Indeed, claim 4, which was cited by the Examiner as providing evidence of "functions being independent of a time delay" in the teachings of Acker '129, recites "means for varying the delay time" (column 18 lines 45-46) of the actuation of transmitters **10**, which means would be useless in the context of the teachings of Acker '129 unless the functions computed by command unit **28** were independent of a time delay between transmitters **10** and component sensors **20**, **22** and **24**; but claim 4 also recites "means for...actuating each said coil with a direct current" (column 18 lines 38-39; emphasis added). Thus, the only context in which Acker '129 teaches the computation of functions of the received signals that are independent of a time delay between transmitters **10** and component sensors **20**, **22** and **24** is the context of DC excitation of transmitters **10**.

By contrast, independent claim 1 explicitly limits the scope of the present invention to time-varying excitation of the transmitters. Part (c) of claim 1 recites:

> transmitting said electromagnetic radiation, using said transmitters, a first of said transmitters transmitting said electromagnetic radiation including at least a first frequency, a second of said transmitters

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> transmitting said electromagnetic radiation including at least <u>a second frequency different from said first frequency</u>, and a third of said transmitters transmitting said electromagnetic radiation including at least <u>a third frequency different from said first frequency</u> (emphasis added)

Thus, claim 1 requires that at least one of the transmitters transmits at a non-zero frequency. The present invention, as recited in claim 1, is based on Applicant's discovery of functions, of the received signals, from which both the position and the orientation of the object can be computed, that are independent of a time delay between the transmitters and the receivers even in the case of time-varying transmissions. For Acker '129 to implement frequency domain multiplexing, he would have to either synchronize transmitters **10** with receivers **20**, **22** and **24** explicitly, as taught in the prior art described in the specification on page 2 lines 3-13, or use the method of the present invention that does not require such synchronization. As noted above, Acker '129 treats only the DC case explicitly. There is neither a hint nor a suggestion in Acker '129 of how to obtain useful functions, of the received signals, that are independent of a time delay between the transmitters and the receivers, in the case of time-varying transmissions. Thus, far from being anticipated by Acker '129, the present invention, as recited in claim 1, is not even obvious from Acker '129.

With independent claim 1 allowable in its present form, it follows that claims 2-6, that depend therefrom, also are allowable.

With regard to independent claim 7, this claim recites a noniterative method of determining the position of a moving object with three independent transmitters of electrical radiation that transmit at respective frequencies, with the frequencies of the second and third transmitters being different from the frequency of the first transmitter, from signals received by three fixed independent receivers, at least one of

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which is spatially extended. Although Acker '129 describes a system in which the receivers are in the moving object and the transmitters are fixed, by reciprocity, this is equivalent to the system of the present invention in which the transmitters are in the moving object and the receivers are fixed. Therefore, to show that claim 7 is not anticipated by Acker '129, it suffices to show that the reciprocal equivalent of the invention recited in claim 7, with moving receivers and fixed transmitters, at least one of the transmitters being spatially extended, is not anticipated by Acker '129. Similarly, to show that claim 7 is not obvious from Acker '129, it suffices to show that the reciprocal equivalent of the invention recited in claim 7, with moving receivers and fixed transmitters, at least one of the transmitters being spatially extended, is not obvious from Acker '129.

Acker '129 teaches against the use of spatially extended transmitters. The object of Acker '129 is to allow the use of spatially localized transmitters, by adjusting the driving currents of the transmitters to keep the received signals within acceptable ranges. This is in contrast with the prior art (US 5,558,091) cited by Acker '129 in column 2 line 41, which uses spatially extended transmitters (Helmholtz coils) to generate field components that are (column 2 lines 46-48)

> either constant, linear or nearly linear with respect to distance in a particular direction within a sensing volume.

Acker '129 states this contrast explicitly, in column 3 lines 42-48:

> Apparatus according to this aspect of the present invention can maintain the detected field parameters at the sensor location, such as the magnitude of the field at such location, within a relatively narrow range even where the field strength varies with a power of distance greater than the first power as, for example, where the field strength varies with the third power of distance from the coil.

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To this end, the algorithm used by Acker '129 to compute the position and orientation of object **14** treats transmitters **10** as point transmitters. This is described explicitly in column 7 lines 49-56:

> Briefly, the magnitude of the fields in each of the local or sensor directions X', Y', Z' represented by each of the component sensors **20**, **22** and **24** is a function of the overall strength of the field from the coil (also referred to as the magnetic dipole moment of the coil), the distance from the particular coil to the sensor and the sensor rotation angles...(emphasis added)

and in Appendix A, in column 15 lines 27-34:

> The theoretical magnetic field for an orthogonal system generated at sensor position pointing to $e_{i[i]}$ direction can be expressed as:
>
> f[coil][i]($x,y,z,\alpha,\beta,\gamma$)(detail abbreviated)
>
> where f is a known function, and includes a dipole moment term having magnitude proportional to the current flow in the particular coil. (emphasis added)

As is well known in the art, a "dipole" is an idealized theoretical construct with no spatial extent. The noniterative algorithm of Appendix A is specific to dipole (*i.e.*, spatially localized) transmitters.

By contrast, independent claim 7 recites both the use of at least one spatially extended receiver and the noniterative inference of both the position and the orientation of the moving object. As explained in the discussion of the prior art on page 2 lines 17-19, the prior art fails to teach noniterative inference of both the position and the orientation of the object when one of the receivers is spatially extended. The same is true of Acker '129. There is neither a hint nor a suggestion in Acker '129 of a noniterative algorithm, for determining both the position and the orientation of a transmitting object, that is suitable for use with a spatially extended

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receiver. Therefore, far from being anticipated by Acker '129, the present invention, as recited in claim 7, is not even obvious from Acker '129.

With independent claim 7 allowable in its present form, it follows that claims 8 and 9, that depend therefrom, also are allowable. Nevertheless, Applicant respectfully points out that the limitations introduced by claim 9 are virtually identical to the limitations of claim 1 that render claim 1 allowable. Therefore, the arguments presented above to demonstrate the allowability of claim 1 also apply to claim 9.

§ 103(a) Rejections - Acker '129 in view of Chau '462 or Besz et al. '845

The Examiner has rejected claims 10-14 under § 103(a) as being unpatentable over Acker '129 in view of Chau, U. S. Patent No. 5,070,462, or Besz et al., U. S. Patent No. 5,099,845. The Examiner's rejection is respectfully traversed.

It is demonstrated above that independent claim 7 is allowable in its present form. It follows that claims 10-14, that depend therefrom, also are allowable.

Amendments to the Specification

An inadvertent typographical error has been corrected on page 2 line 24. Page 2 lines 19-21 describe the prior art correctly: Blood, US 5,600,330, teaches non-iterative calculation of orientation and iterative calculation of position.

An inadvertent typographical error has been corrected on page 10 line 3. Matrix "M" should be italicized and in boldface.

No new matter has been added.

Amendments to the Claims

Claims 1 and 9 have been amended to distinguish more clearly between the first, second and third functions of the components of the signal received by each

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receiver. Just as the function that is required to include signal components received by the receiver from the first transmitter at the first frequency is called the "first" function, so the function that is required to include signal components received by the receiver from the second transmitter at the second frequency now is called the "second" function, and the function that is required to include signal components received by the receiver from the third transmitter at the third frequency now is called the "third" function.

Support for these amendments is found, *inter alia*, in claim 3 as filed, which refers to "said second function" and "said third function". This shows that the omission of the designations "second" and "third" from the function names in claims 1 and 9 was an inadvertent typographical error. In addition, the amendment to claim 1 restores antecedent basis for "said second function" and "said third function" in claim 3.

In view of the above amendments and remarks it is respectfully submitted that independent claims 1 and 7, and hence dependent claims 2-6 and 8-14 are in condition for allowance. Prompt notice of allowance is respectfully and earnestly solicited.

Respectfully submitted,

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Date: August 3, 2000

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